BACKGROUND

USABILITY ANALYSIS OF VIRTUAL LABS

COMPUTE '19

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Virtual Labs project (MHRD initiative)

10 disciplines	70 labs	800 experiments	500 workshops	Used more than 2 million times

What is virtual lab?

- Hands-on activities online that augment classroom lesson
- Use of interactivity and demonstration to promote learning by doing

What is usability?

Technical Usability	Pedagogical Usability
Usability of user-interface elements (for ex: efficiency of use)	Usability of content that aids learning (for ex: allow self-pace)

Motivation

- Usability is a key pre-requisite for online content
- Usability of these virtual labs were suspect

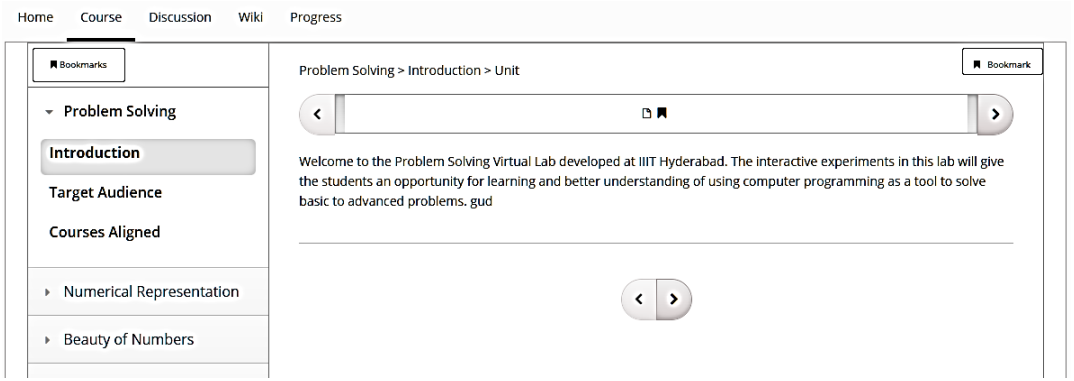
Research Questions

- Are these labs usable?
- Do these labs aid learning?
- How does one create 'useful' virtual labs at scale?

APPROACH

3 labs (~27 experiments) for analysis

- Computer Programming
- Mechanics of Machine
- Cryptography



Leverage technical and pedagogical usability heuristics for evaluation of virtual labs[5][9]

Neilsen's (technical) usability heuristics

T1: Visibility of system status

T2: Match between system and real-world

T3: Consistency
T4: Error prevention
T5: Recognition rather than recall
T6: Flexibility and efficiency of use
T7: Aesthetic and minimalist design

T8: Error diagnosis and recovery by users

T9: Help and Documentation

→ **15 checklist items**

Nokelainen's (pedagogical) usability heuristics

P1: Learner Control

P2: Learner Activity

P3: Collaborative Learning

P4: Goal Orientation

P5: Applicability

P6: Added Value

P7: Valuation of previous Knowledge

P8: Flexibility

P9: Feedback

→ **21 checklist items**

[5] J. Nielsen and R. Molich, "Heuristic evaluation of user interfaces,"
[9] P. Nokelainen, "An empirical assessment of pedagogical usability criteria for digital learning material with elementary school students,"

Score for "Computer Programming" Lab

Technical Usability Checklist Items

When there is error on a page, it is clearly shown (T1)	1
Terms in use are similar to what is used in classroom (T2)	3
A glossary is provided and linked when appropriate ((T2)	0
Experience is similar to other online experiences (T2)	2
Experiments are consistent across the lab (T3)	2
Links that take the user out of the course are clearly labeled (T4)	0
Learner can do experiments without reading instructions (T5)	2
Hints and messages are available at error-prone locations (T5)	1
Experiment is optimized for low-bandwidth usage (T6)	0
Call to action on each page is clearly visible and prominent (T7)	2
Each page element provides unique value and has a purpose (T7)	1
Every page brings to focus critical content and moves less critical content off-screen (T7)	0
All errors have clear messages and provide enough details for learners to resolve them on their own (T8)	1
Quiz shows correct answer when learner is wrong (T8)	0
Context-sensitive help on all screens is available (T9)	0

Rating Approach

- **Rate each lab against each checklist item of a heuristic (0-3)**
- **Calculate score and coefficient of variation for each heuristic**
- **Do this for each heuristic**

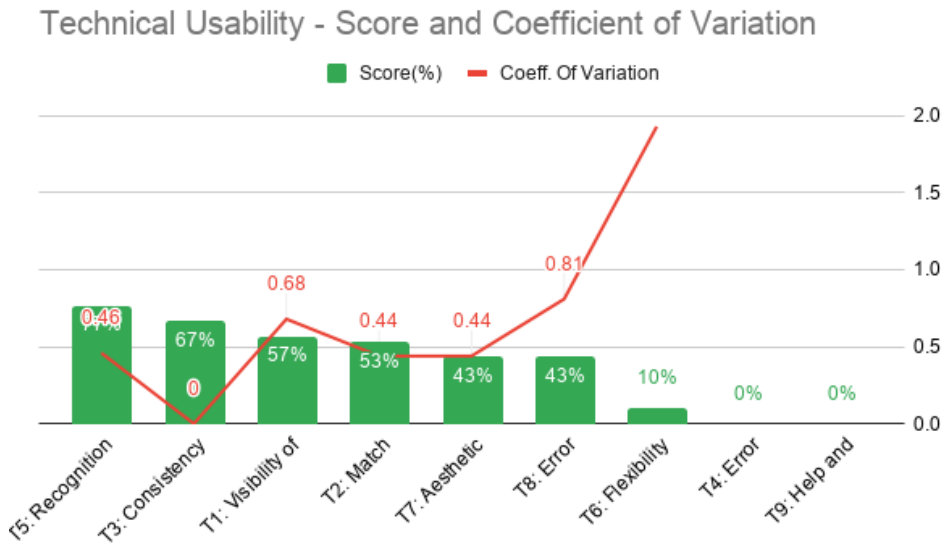
Interpretation of results

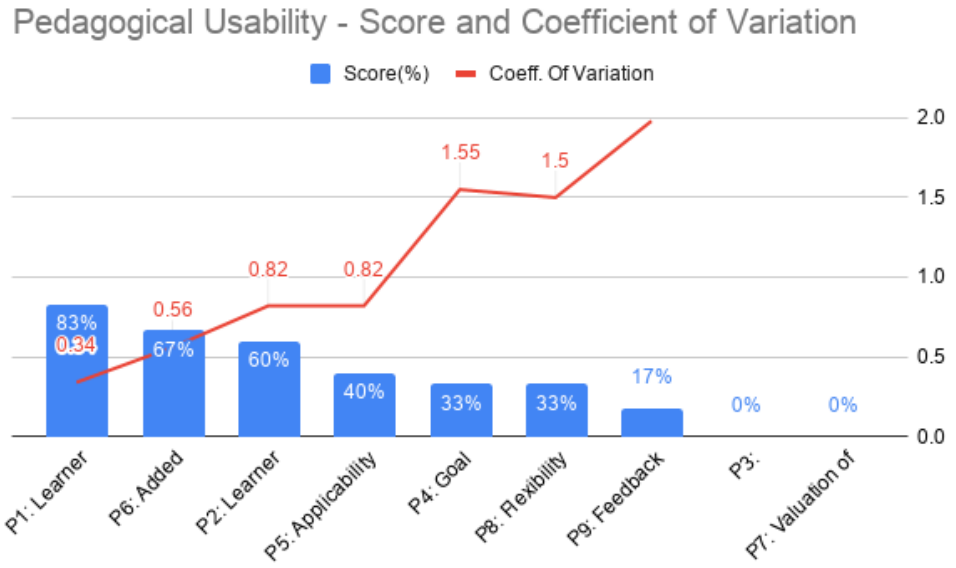
- **Poor score will mean poor design guidelines**
- **High variation will mean poor implementation guidelines**

Pedagogical Usability Checklist Items

Each experiment covers a manageable chunk of information (P1)	2
Each simulation is broken down into small chunks (P1)	3
Learner can set their own hypothesis (P2)	0
Learner can select their own input data (P2)	3
Multiple users can work together on a lab (P3)	0
Lab objective is clearly laid out, including measure of achievement (P4)	3
Experiment allows students to set their own goals in pursuit of overall objectives (P4)	0
Take real-life examples in experiments (P5)	1
Build on something that the learner already knows and introduce new material (P5)	2
Creative use of multimedia to aid in learning (P6)	1
Allow self-pace (P6)	3
Use techniques to teach that can only be done using a computer (P6)	2
Provide some personalization based on what student already knows (P7)	0
Provide multiple paths based on what student already knows (P7)	0
Navigation free to any part of the experiment (P8)	3
Multiple assignments available to choose from (P8)	0
Multiple types of multimedia content so that student can choose what they like the most (P9)	0
Frequent quizzes within the simulation (P9)	0
Immediate feedback (P9)	2
Track score and gamify it (P9)	0
Peer feedback is available (P9)	0

EVALUATION AND ANALYSIS





Variation

Low score, high variation
- Error diagnostic and recovery by users
- Goal orientation
- Applicability
- Flexibility
- Feedback

High score, high variation
- Visibility of system status
- Learner Activity

Low score, low variation
- Error prevention
- Flexibility and efficiency of use
- Aesthetic and minimalist design
- Help and Documentation
- Collaborative Learning
- Valuation of previous knowledge

High score, low variation
- Match between system and real-world
- Consistency
- Learner Control
- Recognition rather than recall
- Added Value

Score

Observations and Conclusions

There is a lack of overall focus on usability

There are Missing/Incomplete design guidelines

There are Missing/Incomplete implementation guidelines

More than 70% of heuristics fared poorly (13/18)

More than 60% of the heuristics have low scores (11/18)

More than 55% of the heuristics have high variations (8/14*)